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Method and Apparatus for Recording, Measuring, and Documenting Damages, in Particular Deformations on Painted Surfaces Caused by Sudden Events

The invention relates to a method for recording, measuring, and documenting damages, in particular deformations such as depressions or the like, that are caused by sudden events, for instance hailstorms, to painted surfaces, in particular body parts of vehicles, in which the surface to be examined on the vehicle is scanned with light from at least one highly focusing light source in a lattice- or grid-pattern and with the light reflected on the surface a surface image is produced on a screen, which is recorded by an evaluation and signal processing device and in this the surface damages are determined using a certain evaluation algorithm and are output for objectively documenting the damages.

The invention furthermore relates to apparatus for recording, measuring, and documenting damages, in particular deformations such as depressions or the like that are caused by sudden events, for instance hailstorms, to painted surfaces, in particular body parts of vehicles, with a highly focusing light source for illuminating a surface having deformations or damages to painted body parts of a vehicle, a deflection device for the light for linear and grid-pattern scanning of the surface, a screen for imaging the surface by means of light beams reflected by the surface, means for recording the images, a processor for processing and evaluating the images recorded, and means for displaying and outputting the results.

Frequently, especially in the summer months, it is not possible to put vehicles away in time when there is a hailstorm. These vehicles, especially new or unused passenger vehicles, delivery trucks, or the like, sometimes suffer significant damages from depressions and/or dents on their roofs, hoods, trunk lids, fenders, doors, spoilers, sides, and/or roof rails. Small, barely visible dents particularly lower the sale or re-sale value of a passenger vehicle damaged in this manner. While insurance generally takes care of broken front and rear windshields and side windows in the settlement process, and even deep dents are agreeably settled after a proven hailstorm, small and barely visible depressions frequently lead to frustrating and acrimonious

disagreements among the parties involved. In addition to the party that suffered the damages, the parties involved are the damage assessor, the claims adjustor for the insurance company, and especially the company that is to restore the value of the damaged automobile with appropriate repairs.

In the past no objective measurement and evaluation method was available for damages caused by hailstorms to painted surfaces, in particular body parts of motor vehicles, that objectively described and documented the damages and also the quality of the repairs performed.

Known from DE 24 39 988 A is a method for recording locally-limited deformations on curved surfaces, in particular on surfaces of pressed body parts for motor vehicles, in which the surface to be examined is scanned with bundled light in a lattice and grid pattern. The light lattice or grid is detected at a different angle than the angle of impact of the light in the form of an image that is mathematically analyzed with respect to locally limited distortions to the lattice or grid. The light used comprises laser light. For performing the known method there is a light beam generator, a scanning device for guiding the light beam in a lattice- or grid-pattern over the surface to be examined, a remote-control camera with monitor directed at the surface at a different angle than the light beam, and an analysis unit evaluating the image on the monitor.

Primarily individual body parts or components are analyzed for deformations using this known solution. The method is tied to the production process, and is thus stationary and bound to the site. Its use on damages to vehicle bodies caused by sudden events like hailstorms has not been considered in the past because it is necessary to scan the entire vehicle body, for which the known technical teaching provides no solution, and there is not adequate mobility.

Given this prior art, the invention is based on the object of providing a method and an apparatus of the type cited in the foregoing with which it is made possible to objectively describe, evaluate, and document damages to painted surfaces, in particular bodies of motor vehicles, which damages are caused by sudden events such as hailstorms, and their repair.

This object is attained using a method of the type cited in the foregoing with the characterizing features of claim 1 and using apparatus with the characterizing features of claims

19 through 21. Advantageous designs of the method and the apparatus can be found in the dependent claims.

The inventive method is distinguished in that first of all it is possible to objectively measure, record, and document for all parties involved damages, such as small surface-area depressions, to painted body parts, which damages were caused by hailstorms. Furthermore, appropriate repair and maintenance of the damaged vehicle can be demonstrated with the inventive solution. Of particular advantage is the mobility attained with the inventive solution, by means of which it is possible to undertake a cause-related damage assessment within a short period of time after a hailstorm strikes.

By using a focused light beam, for instance a laser beam with a small spot diameter, a very high resolution of , i.e., precision in, the image of the damaged surface can be attained. The inventive method furthermore attains a very high scanning speed so that the entire surface of a body can be imaged and analyzed in a very short period of time.

The inventive apparatus furthermore realizes a simple, robust, and yet safe scanning concept with laser light sources that can travel and pivot horizontally and vertically along braces of a support frame and whose movement is coordinated with the movement of the vehicle. Thus the entire body surface can be inspected, imaged, analyzed, and certified for damages in a single work step.

The inventive apparatuses are compact and simple in structure, the functional units are easily understood and arranged freely accessible for assembly and maintenance purposes.

The invention shall be explained in greater detail in the following using a number of exemplary embodiments.

Fig. 1 is a representation of the inventive method that illustrates its principle;

Fig. 2 illustrates the typical beam path for the laser beams on a deformed body surface; and

Fig. 3 illustrates a variant of the support frame with integrated inventive apparatus.

Fig. 1 illustrates a schematic depiction of the principle of the inventive method in which the damages to the roof of a passenger vehicle, damages for instance from a hailstorm, are to be determined, evaluated, and documented. High-gloss painted surfaces reflect laser light striking them. The laser light beam 2 produced by a surface scanner 1 is directed onto the surface 3 of the vehicle 4 to be examined and is guided over the surface 3 using a conventional deflection device. The laser light beam 2 strikes the surface 3 and is reflected there corresponding to the Law of Reflection in optics, according to which the angle of incidence is equal to the angle of reflection relative to the surface normals of the just stricken surface element . The reflected laser light beam 2 strikes a flat screen 6 on which the scanned surface becomes visible. The accuracy of the image and the recognizability of small details is largely a function of the diameter of the laser light beam 2, whereby the smaller the diameter of the laser light beam 2, the higher the resolution. Thus, for the inventive method, the advantages of laser engineering for simply generating highly bundled light are fully in play. This does not mean, however, that the inventive method is limited to laser light. On the contrary, the invention also includes the use of other light sources if these are suitable for self-focusing. If the laser light beam 2 moves over the surface 3 to be examined, on the screen 6 a line 7 appears that represents a precise image of the line traveled on the surface 3. Even the smallest local deviations from the surface lead to clear notches in the otherwise uniform line of an undamaged surface. If the screen 6 is positioned at a farthest possible distance A from the surface 3 to be examined, a corresponding enlargement of the image can be obtained. A uniform curve in the surface, as occurs for instance on a vehicle roof or fender, is likewise imaged as a continuously curved line. If there are depressions in the surface 3, these disturbances to the surface become visible due to notches in the line. This is depicted in Fig. 2, which illustrates a typical path for a beam on a deformed body surface. In Fig. 2, n indicates the beam path with a depression 8 and m indicates the beam path without a depression 8 in the surface 3.

Assigned to the screen 6 is recording means, for instance a digital camera 9, that is used to digitally record the image of the surface 2 produced by the surface scanner 1. The digital image information is forwarded from the digital camera 9 to an evaluation and signal processing device 10 for storage, by means of which device analysis is performed for determining the damage. The evaluation results are displayed on the monitor 11 and output with a printer 12 as a measurement record.

In the present example illustrated Fig. 1, the surface 3 of the entire vehicle roof is scanned and recorded as image information and stored in the microprocessor 13 of the evaluation and signal processing device 10.

Characteristic image information for an undisturbed surface 3 of a comparable body is stored in the microprocessor. The measured image information is compared to characteristic image information. The degree of the deviation between the measured surface profile and the comparison signature for the undisturbed surface is a measure for the type and scope of damage.

Example 1

Fig. 3 illustrates the design of the inventive method within a container-like support frame 14 in which the vehicle 4 to be tested is situated.

This support frame 14 largely comprises the upper lateral braces a and b, the lower lateral braces c and d, the front end braces e, f, g, and h, and the rear end braces i, j, k, and l put together. One of each type of side brace, a vertical and a horizontal side brace, are joined to one another in a surface fit using corner fittings. The side walls are pivotably hinged at the lower side braces o and d and the lower side braces f and j so that at the set-up location the support frame 14 is freely accessible on all sides by opening the side walls 15.

Mounted along the upper side braces a and b, the front upper horizontal and vertical end braces e, g, and h, and the rear horizontal and vertical end braces i, k, and l, are guide rails 16 that guide the surface scanner 1 and the screen 6. The surface scanner 1 is driven for instance by a step motor (not shown) and is moved horizontally and vertically in the guide rails 16. The surface scanner can also make a pivoting movement using an appropriate tilt apparatus. An

argon or krypton ion laser with output capacity in the range of a few 100 mW in the TEMoo mode and a spot diameter of less than 0.5 mm is used so that structural differences of < 0.5 mm can be detected and documented. Given a linear distance of 0.5 mm, as well, depressions 8 of this magnitude can be analyzed. For instance, a surface area of 2 m x 2 m can be scanned in a few seconds using a beam excursion of +/- 1000 mm both in the longitudinal and in the transverse direction.

Even with a line deflection frequency of 1000 Hz, at a line feed of 0.5 mm on a length of 2 m only 4000 lines have to be traveled. This means that in 4 seconds a complete image of the 4-m^2 surface is available on the screen 6.

The vehicle 4 to be examined drives into the support frame 14 onto a measurement table 17 and is anchored there by means of attaching means 18 that are attached to the measurement table. Using a lifting mechanism (not shown), the measurement table 17 and the vehicle 4 are lifted to a height at which the vehicle can perform a pivoting or rotational movement about its longitudinal axis A-A with no problem.

A screen 6 made of matte glass is suspended in the guide track 16 opposing the surface scanner 1and set up at an angle inclined -45° such that the entire surface of the vehicle 4 can be imaged on the screen 6.

The vehicle 4 together with the measurement table 17 is then pivoted or caused to rotate about the longitudinal axis A-A using a suitable drive so that the surface 3 of the vehicle 4 reflects the laser beams emitted by the surface scanner 1 and are deflected to the screen 6. Assigned to the screen 6 is a digital cameral 9 that was omitted in Fig. 3 for reasons of simplicity (see also Fig. 1). Processing, evaluation, and documentation of the scanned surface 3 of the vehicle 4 is performed corresponding to the process described in the foregoing. The drive assemblies for the displacing and pivoting movement of the surface scanner 1 and the screen 6 and for the rotational or pivoting movement by the vehicle 4 are controlled by a separate processor unit 19 so that it is assured that the movements correlate for scanning the body surface.

The evaluation and signal processing unit 10, monitor 11, printer 12, microprocessor 13, and processor unit 19 for the coordinated control of the drives are located in a separate space 20 that is divided off from the support frame 14. Once the measurements and evaluations have concluded, the vehicle 4 together with the measurement table 17 is lowered, the measurement table 17 is locked, the vehicle 4 is released from its anchoring and driven out of the support frame 14. When the side walls 16 are flipped up, the support frame 14 is closed on all sides and thus after it is loaded onto a truck or semi-trailer truck it can be taken to the next location.

Example 2

The structure of the inventive apparatus in Example 2 is largely the same as that in Example 1. The difference is that the vehicle 4 is not lifted and does not make a rotational or pivoting movement. The body surface is scanned in that, for an immobile or moved vehicle, only the surface scanner 1 performs a displacement movement in the horizontal and vertical direction and the screen 6 is brought into the corresponding intercepting position for the reflected laser light beams 2.

Key to reference numbers used

Light source, surface scanner	1
Laser light beam	2
Surface of body	3
Vehicle	4
Reflected beams	5
Screen	6
Line	7
Depression	8
Digital camera	9
Evaluation and signal processing unit	10
Monitor	11
Printer	12
Microprocessor	13
Support frame	14
Side wall	15
Guide rails	16
Measurement table	17
Attaching means	18
Processor unit	19
Communication and operator space for 14	20
End wall	21
Distance from surface to screen	A
Longitudinal axis of vehicle 4	A-A
Upper lateral braces for 14	a, b
Lower lateral braces for 14	c, d
Front side braces for 14	e, f, g, h
Rear end braces for 14	i, j, k, l
Path of beam with depression 8	m
Path of beam without depression	n

3 pages of drawings